Effects, Processes and Perceptions of Spring Particulate Episodes in the UK

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1. Abstract

In March-April 2014 the UK experienced high levels of PM10 and PM2.5 as part of a common annual air pollution event called a Spring particulate episode. Two distinct time periods of high particulate matter (PM) concentration during March and April 2014 were thought to be the cause of an increased mortality rate and hospital admissions across the UK. This particular Spring particulate episode in 2014 was the centre of media attention due to its physical property of Saharan dust which caused much of London and South-East England to experience dust-fall during the episode. Although this episode was heavily publicized, others before it were not even though many of them matched or exceeded the PM concentrations seen in April-March 2014. Here we look to investigate the cause, effects and public perceptions of such episodes and the policies surrounding them. Taking raw AURN data and using the R package ‘Openair’ to visualise that data allows the finding of how this Spring particulate episode came to be and exactly where the polluted air mass originated. Data from the Office for National Statistics (ONS) and St John’s Ambulance were used to gain an insight into the death rate as well as the demand for emergency treatment during this time. Evidence of the public’s interest in this particular episode and its disinterest in others like it was explored using Google Trends data. The UK has improved air quality substantially over decades of policy change and continue to do so, meeting targets set by the European Union (E.U) and World Health Organisation (WHO). However, every year premature deaths and reductions in life expectancy occur due to poor air quality with an estimated 40,000 deaths attributed to air pollution annually in the UK. Periods of unacceptable air quality occur more often than one might think.

2.1 Keywords

Keyword	Description
R	Statistical programming language
Openair	Package within R used to manipulate air pollution data
Particulate Matter	Solid or liquid particles suspended in air for an appreciable amount of time
PM10	Particulate matter of less than 10 microns in diameter
PM2.5	Particulate matter of less than 2.5 microns in diameter
AURN	The Automatic Urban and Rural Network. It monitors air pollutant concentration, wind direction and magnitude at over 300 sites across the UK.
Defra	The Department of Environment, Food and Rural Affairs

COMEAP	The Committee of Medical Effects from Air Pollution
EU	European Union
UK	United Kingdom
PHE	Public Health England
WHO	World Health Organisation
St Johns Ambulance	Work alongside the NHS in response to 999 calls
NHS	National Health Service, based in the UK
ONS	Office for National Statistics, based in the UK
CatA	A category A incident is one which St Johns Ambulance deem life threatening

2. Introduction

2.1 Background & Theory

Spring particulate episodes occur most years in the months of March and April in the UK. They are categorised as periods of high PM10 and PM2.5 concentration. These episodes are thought to be caused by a combination of emissions from agriculture, transport and industry built up across Europe and then transported to the UK by Easterly winds [1]

PM10 and PM2.5 are defined as particulate matter (PM) of diameters less than 10 microns and less than 2.5 microns respectively. Particulate matter refers to any mixture of solid particles or liquid droplets that remain suspended in the atmosphere for appreciable time periods [2].
Particulate matter come in various forms, the most common of which are dust, fly ash, soot, smoke, aerosols, fumes, and mists such as sea spray [3]. The most common sources of PM in the atmosphere are power plants, industrial factories and diesel vehicles [4]. Nitric Oxide (NO) and Nitric Dioxide (NO2) are chemicals closely related to PM such that they contribute to air pollution and poor human health by the same sources and through the same mechanisms in which PM does, however, this investigation focuses on PM as it was the main contributor to the poor air quality within the UK during this episode.

Due to PM10 being larger than PM2.5, its risk to human health is lower. PM10 can be filtered by nasal fibres due to its size and when inhaled orally, cannot penetrate the lungs. However, PM10 can still induce tissue damage, and lung inflammation through deposition on the surfaces of the larger airways of the upper region of the lung [5]. PM2.5 is more likely to evade filtration, reach the deeper parts of the lungs and deposit there. Young infants, Asthmatics and elderly sufferers of lung and heart diseases are the worst effected by PM exposure. Short-term effects include the worsening of pre-existing conditions such as Asthma, acute Bronchitis and respiratory symptoms which can lead to hospital admissions. Long-term exposure to PM2.5 has been linked to premature death in sufferers of chronic heart or lung diseases, and reduced lung function growth in children. Long-term effects of PM10 exposure is an area of investigation. Evidence suggests a link between long-term PM10 exposure and respiratory mortality [5].

E.U legislation establishes standards of air quality in Europe. Thresholds define unacceptable levels of PM10 to be greater than a 50 µg/m^3 average over 24 hours with a permitted exceedance of 35 times per year and a 40 µg/m^3 average over the course of a year. For PM2.5 this limit is a 25 µg/m^3 average over a year with an objective to reduce concentrations by 15% in urban background sites by 2020, which was achieved in the UK [6].

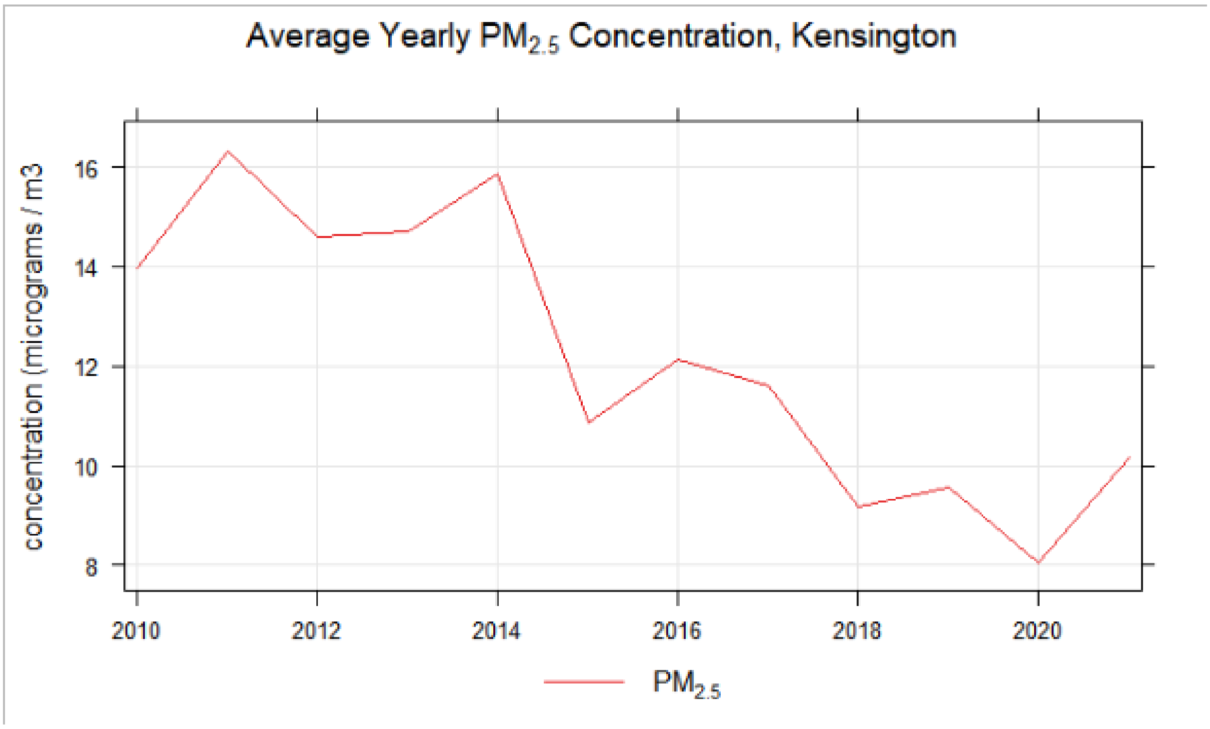

Figure 1: Graph showing the annual average PM2.5 concentration in Kensington, London 2010-2021

In 2019, Public Health England (PHE) published a review of evidence on how to improve air quality in the United Kingdom [7].. They listed four key interventions local governments could make to reduce PM emissions and improve air quality:

- "promoting a step change in the uptake of low emission vehicles - by setting more ambitious targets for electric car charging points, as well as encouraging low emission fuels and electric cars"
- "boosting investment in clean public transport, as well as foot and cycle paths to improve health"
- "redesigning cities so people aren't so close to highly polluting roads"
- "discouraging highly polluting vehicles from entering populated areas - for example, with low emission or clean air zones"

Public Health England publishes air pollution evidence review - GOV.UK (www.gov.uk).

As reflected in PHE's key interventions, petrol and diesel vehicles are recognised as one of the greatest contributors to PM pollution that can be reduced the most effectively through abandonment or uptake of low emission vehicles. It is thought that cars contribute 18% and transport in general contribute 33% of all air pollution in the UK, which is why it is a major component in the UK's battle to become a net-zero nation in regards to greenhouse gases [8]

Other than vehicular emissions, the energy sector and factory industry contribute a large amount of air pollution including PM within and outside of the UK. Steps to reduce pollution in the energy sector include the use of clean, renewable energy systems such as wind turbines and solar panels to produce energy. Alternatively, nuclear power stations have cleaner waste products than coal power plants and are much more efficient. Reducing factory emissions are costly and inconvenient. Methods of reducing PM waste from factories would include optimization of the factories operations and destroying pollutants before they leave the site through oxidizers [9]. However, these methods have an expense that, for now, outweigh their need.

2.2 Motivation & Importance

Motivation for this study arises from the COMEAP (The Committee of Medical Effects from Air Pollution) figures regarding human health and air pollution. COMEAP believe that about 40,000 deaths occur in the UK annually due to air pollution and of those, 28,000 due to PM inhalation [23]. Also, hospital admissions, death acute and chronic conditions are caused by short-term and long-term exposure to PM10 and PM2.5. It is important for the public to be aware of the risks associated with exposure to air pollution and particulate matter, especially if they or someone they know suffer from Asthma or any chronic lung or heart diseases. With caution, many of these death per year could be avoided by being aware of the air pollution in public areas. As well as public awareness, the UK government, EU and air quality organisations must continue enforcing policies that work towards the reduction of air pollution. This is achieved through strict auditing of polluting companies and policy changes. The UK have reduced their air pollutants emissions greatly since the 1970’s and need to continue to ensure a healthy, liveable country is left behind for future generations

3. Methods

3.1 Air Quality Data

21 monitoring networks are publicly accessible through the Defra (Department for Environment, Food and Rural Affairs) website [10]. The monitoring network used within this investigation was the Automatic Urban and Rural Network (AURN), of which their purpose is to monitor the populations exposure to air pollution. Data spanning decades including wind direction, magnitude and pollutant concentration are freely available via the Openair package within the statistical computing language R. AURN comprises of around 300 sites across the UK classified into rural, urban roadside, urban background or industrial, depending on their location.

In this study, two sites are used; Kensington, London and Rochester Stoke. These two sites, urban and rural background respectively, are modelled over the years of 2011 and 2014.

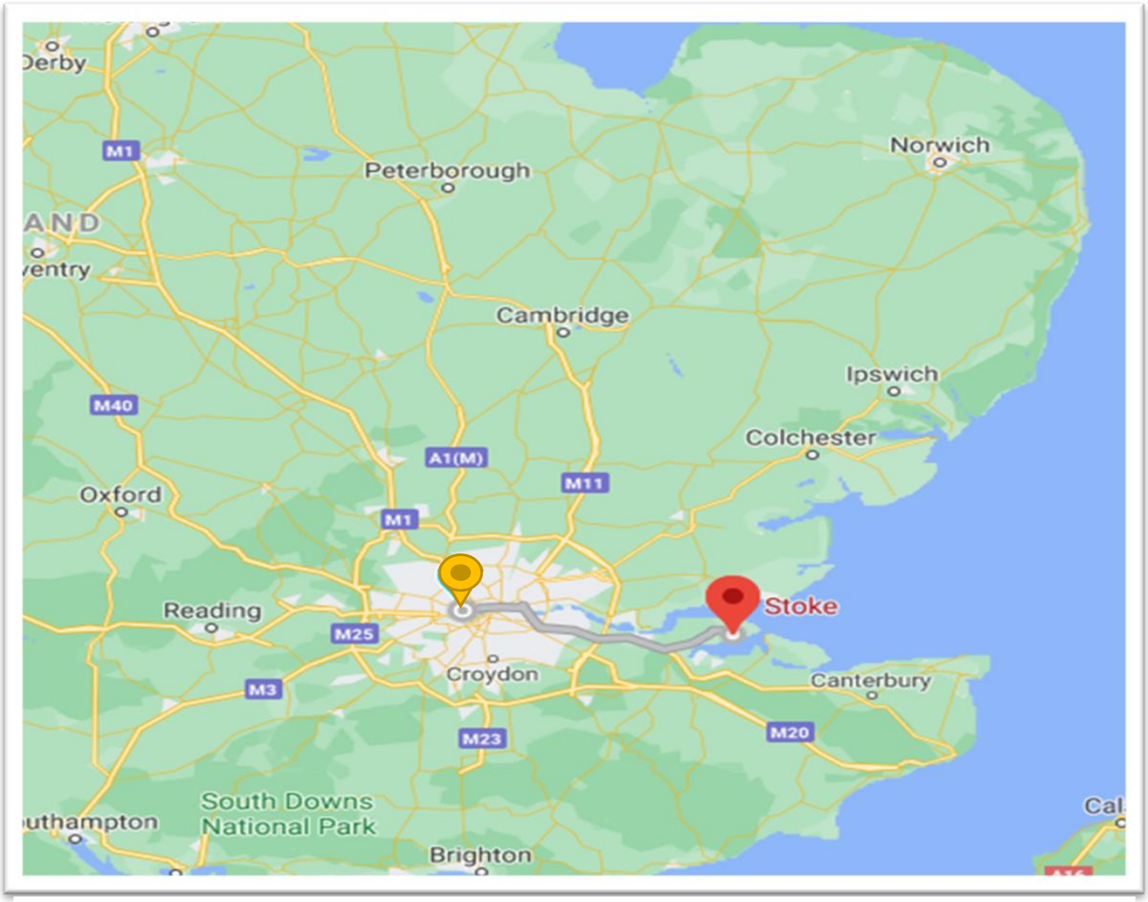

Figure 2: A Google Maps screenshot of South-East England with the Kensington, London site marked in yellow and the Rochester stoke site marked in red.

However, most insight is gained through focusing on the weeks preceding and during the particulate episodes in question. It was important to choose an urban and rural site to compare and observe whether the PM concentrations were high regionally or just locally. There were very few rural background sites of which AURN measured both PM10 and PM2.5 during the timeframe investigated. Rochester Stoke was chosen as it was located within the highly effected South-East of England however, being upwind from London meant there was a possibility that these two sites could share the same PM concentrations locally produced in London. Ideally, a rural background site downwind of Kensington in South-East England such as Chilbolton Observatory would have been used had it been monitoring PM10 and PM2.5 concentrations during the episode.

3.2 Openair Functions

Four main functions of Openair are used to model PM10 and PM2.5 concentration as well as wind direction to gain insight into the processes of the episodes. The timePlot function was used to model pollution concentration by time. PollutionRoses were used to gain insight into the pollution concentration by wind direction. A WindVector timePlot was used to visualise wind direction and magnitude by time and pollution concentration. Finally, a Hysplit was used to complete a back trajectory analysis to determine the origin of polluted air masses [11].

The first aim was to find data that could give insight into the magnitude of poor air quality that was experienced across the UK in March - April 2014. This was accomplished using a timePlot on the scale of 2 months for Kensington and Rochester Stoke, measuring both

PM10 and PM2.5 concentrations. Using the same function but for a smaller timescale meant the episode could be interpreted with finer detail.

Once the episode was identified, other pollutant data was examined to ensure that PM10 and PM2.5 were the main contributors to the poor air quality. The urban and rural background sites were compared within as well as outside of the time of the event to establish how much of the particulate pollution was shared between the two sites and whether the pollution may have been produced at one of the sites. Contributing to this effort, pollutionRoses were created to show from what direction both sites had contributions of PM, again, both within and outside the time of the event.

Referencing the Defra Annual Report from 2014 [12] it was confirmed that the reason for the episode of poor air quality within the UK was an importation of polluted air mass from Europe due to south-easterly winds. To visualise and understand the relationship between the wind direction and magnitude and the PM concentration in the UK, a windVector timePlot was created.

A Hysplit was calculated to find exactly where from Europe the contributions of PM originated and how they were transported through the continent. “The model calculation method is a hybrid between the Lagrangian approach, using a moving frame of reference for the advection and diffusion calculations as the trajectories or air parcels move from their initial location, and the Eulerian methodology, which uses a fixed three-dimensional grid as a frame of reference to compute pollutant air concentrations” [13] (HYSPLIT – 2 – Air Resources Laboratory (noaa.gov)) .

3.3 Mortality, Hospital Admissions & 999 Emergency Call Data

Data describing death and hospital admissions were used to observe the relationship between this high pollution episode and its health effects through the Office for National Statistics (ONS). The data from the ONS compared the death toll and hospital emissions for the 2014 Spring particulate episode to those of an average outside of a period of high PM concentration. Data from St Johns Ambulance was used to gain insight into the volume of 911 emergencies involving respiratory and cardiovascular illnes before and during the Saharan dust episode as well as providing an insight into the strain these cases put on the service. Statistics from COMEAP were used to evaluate the human health effects of poor air quality across the UK in general.

3.4 Google Trends

Google trends data was used to gauge the public interest of the events by gaining an insight into the volume of searches of certain phrases by time. Relative to this investigation, the phrases ‘Air Pollution’ and ‘Air Pollution Effects on Health’ were used for UK Google searches from 2006 - 2021. Displaying the results graphically exhibited peaks or troughs of high or low interest in the phrase.

4. Results & Discussion

4.1 Cause of Episode

Figure 3 shows the daily concentrations of PM10 and PM2.5 for the 2 months of March - April 2014 for both Kensington, London and Rochester Stoke. Two peaks in PM concentration are evident before and after the 31st March. These peaks, combined with that of the 13th March 2014, were linked to around 600 deaths and 1,500 hospital admissions across the UK, COMEAP estimate.

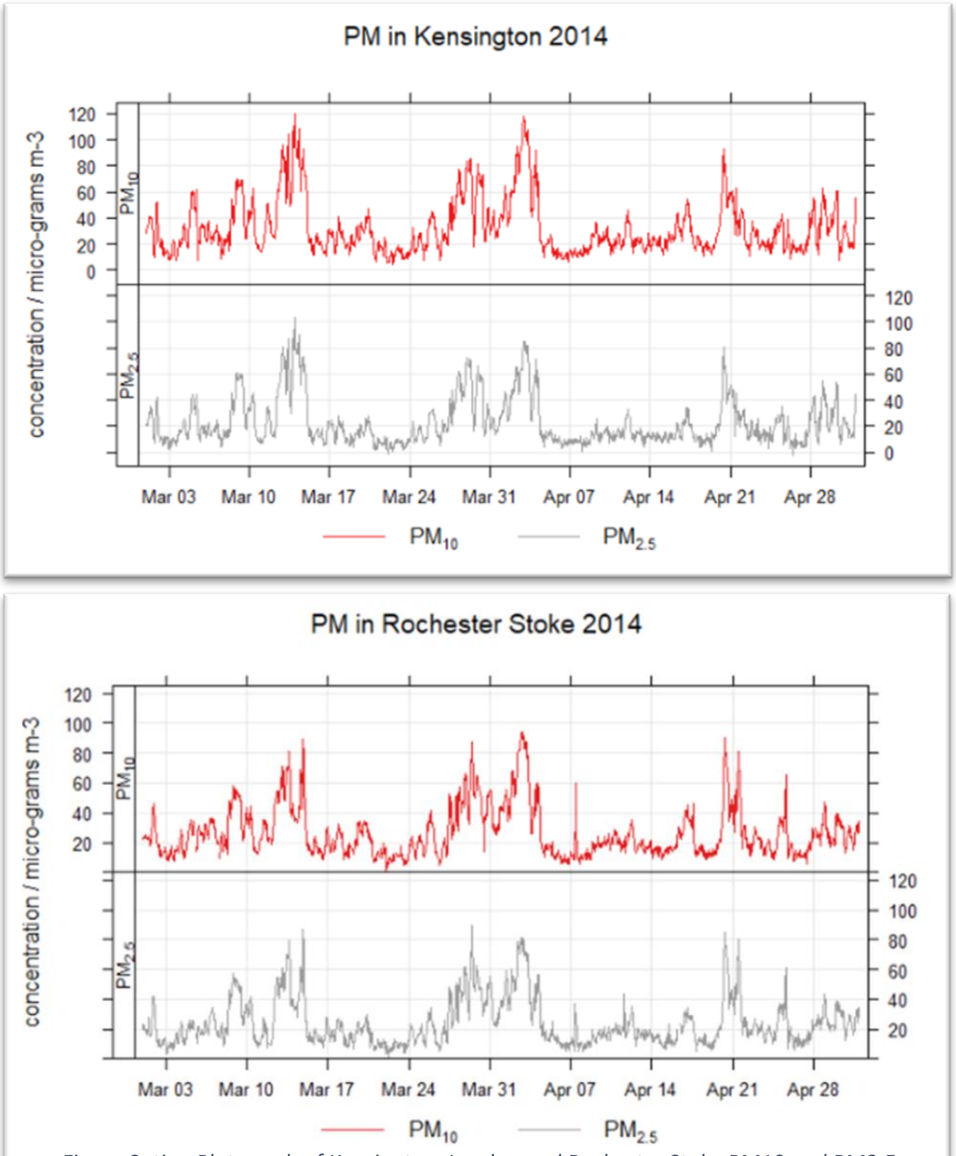

Figure 3: timePlot graph of Kensington, London and Rochester Stoke PM10 and PM2.5 Concentrations March – April 2014.

Comparing Kensington and Rochester Stoke, the timePlots are almost identical to each other in magnitude as well as pattern strongly suggesting that the high levels of PM10 and PM2.5 may have been shared regionally across multiple sites. Note that the PM10 concentrations in both Kensington and Rochester Stoke exceeded the daily average limit set by the EU of 40μg/m^3 several times over the course of these two months, sometimes for days at a time reaching highs in Kensington of 119μg/m^3. Levels of PM2.5 concentration also regularly exceeded the EU lit of 25μg/m^3 in both Kensington and Rochester Stoke.

PM10 and PM2.5 concentrations often share the same patterns as they share the same mechanisms of transport and originate from the same sources. These episodes may have arisen from a local source in London and been transported upwind to Rochester Stoke, however we know that these levels and patterns were shared by sites across the UK indicating a polluted air mass transported across the entire region.

Figure 4 shows the pollutionRose's for Kensington and Rochester Stoke for 2014. The imported PM2.5 concentration for these two sites are represented as colours, red being high concentration and blue as low concentration. The radial direction of these 'petals' show the direction the pollution was received from, with North being vertically upwards. Lastly, the size of the petal represents the percentage of the overall pollution that has been contributed from that direction.

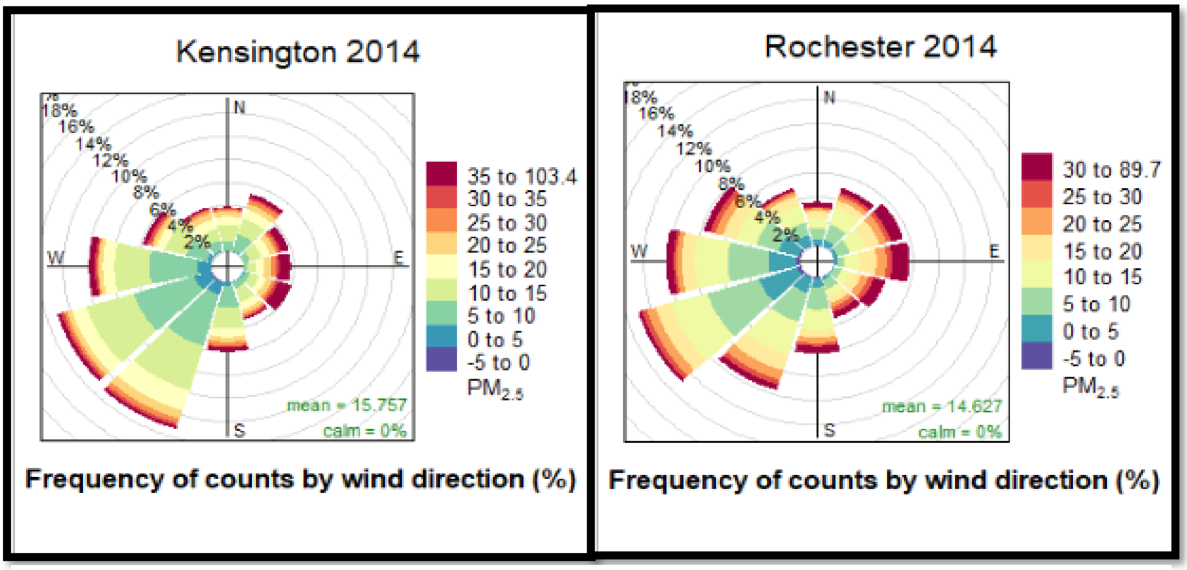

Figure 4: pollutionRose for Kensington and Rochester Stoke PM2.5 taken over a yearly average, 2014

Here, the modal direction of transported PM2.5 across the entirety of 2014 was South-West, South-West-South and West. This indicates that of all directions in which PM2.5 was transported into these sites, these directions contribute an average of 34.5% of the total. A large portion of PM2.5 (and PM10) was received from the South-West. On average, this is expected as the UK experiences South-Westerly prevailing wind from the Atlantic Ocean all year round. In Figure 5, the pollutionRoses of the episode differ greatly.

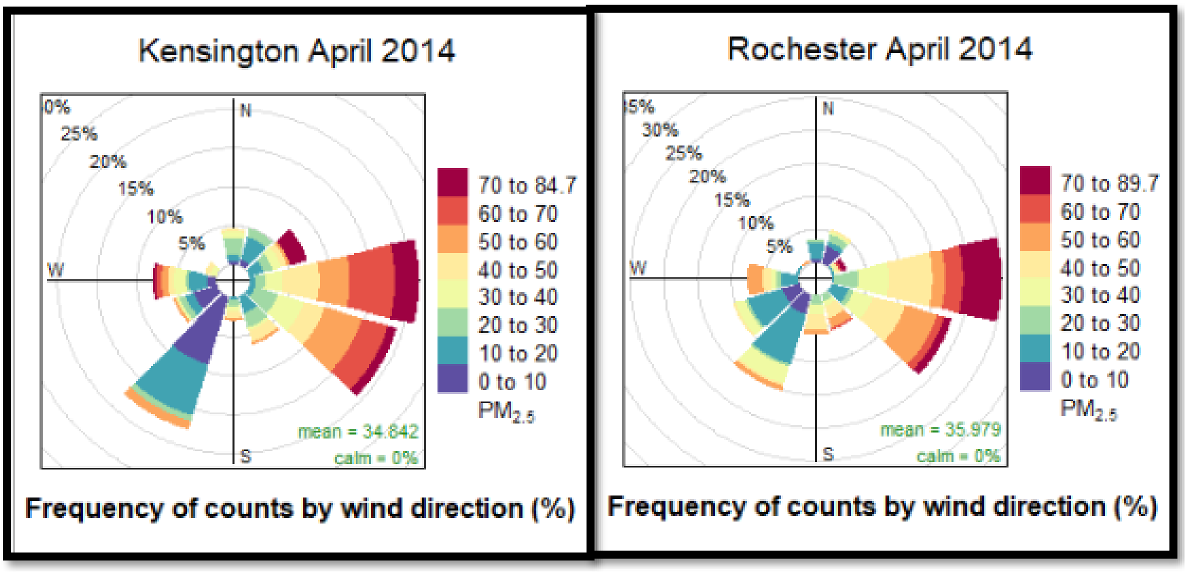

Figure 5: pollutionRose of Kensington, London and Rochester Stoke the week of the episode 31/3/14 – 4/4/14

In Figure 5 it is apparent that contribution of high concentration PM2.5 from the East and South-East is dominant from the 31st March – 4th April indicating a polluted air mass arriving from Europe. The cause of this was a change in wind direction as mentioned in the Defra Annual Report from 2014 [12]. In addition, we can see within the pollutionRoses there is a given average concentration for PM2.5 over this time period. The annual average for 2014 for Kensington was 15.8μg/m^3 and the average during the time period of the Sharan dust episode was 34.8μg/m^3. The Saharan dust episode exhibited PM2.5 concentrations 2.2 times that of the yearly average.

Date	Event Description
28th March	Easterly wind brought polluted air mass from Europe.
29th March	Combined with a calm sunny day, trapping local pollution.
30th March	A slight increase in southerly wind speed decreased pollution levels in the south and increased them in the north.
31st March	An air mass which had travelled up through France via the Sahara arrived in the UK. The polluted air mass travelled north throughout the day.
1st – 3rd April	A light southerly wind brought urban and industrial pollution from France arrived in the UK Throughout the episode exhaust emissions, both continental and local, were identified as a major component of the pollution.
4th April	Overnight, light winds from the Atlantic started to slowly disperse the pollution.

Figure 6: A table reproduced from Defra's description of the Saharan dust event 2014 [Annual Report 2014 Issue 1 Online Viewer - Defra, UK]

Figure 6 presents data from Defra's Annual Report reproduced into a table. How the wind direction and magnitude effected the PM2.5 concentration in Kensington was understood more visually using a windVector timePlot.

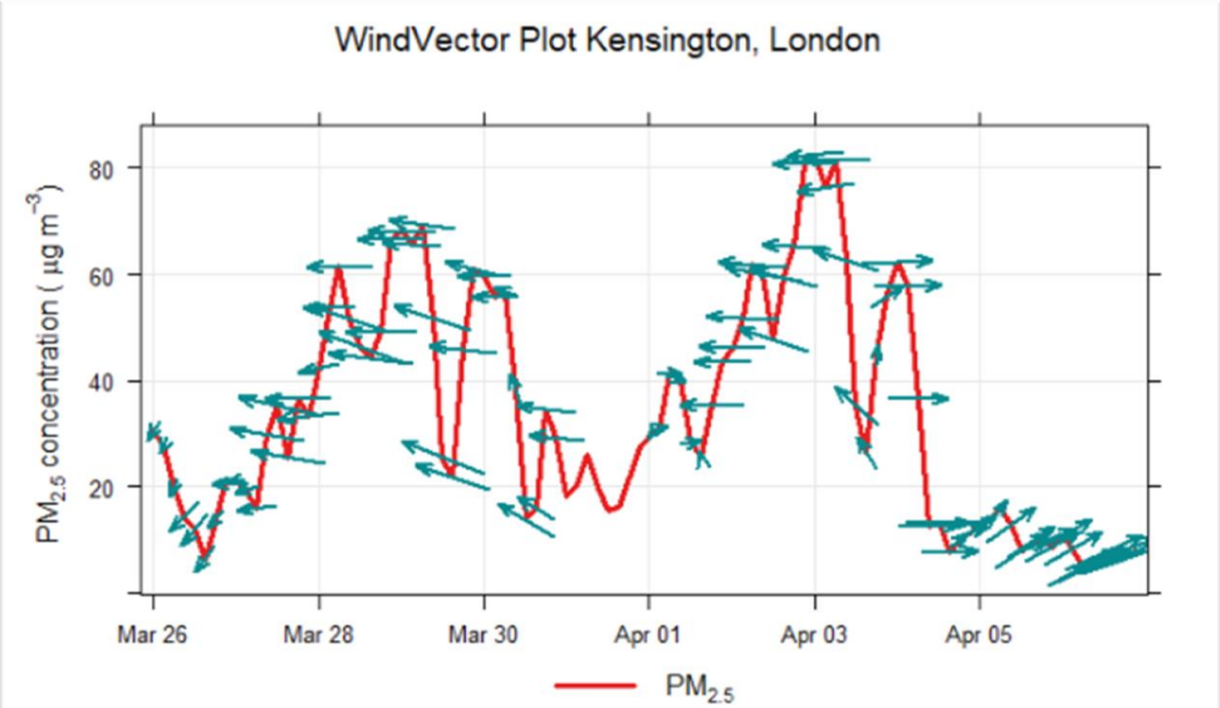

Figure 7: A windVector timePlot of PM2.5 in Kensington, London 26/3/14 – 8/4/14

Figure 7 validates Figure 6 by its presentation of Easterly wind from 27th – 30th March and correlating rise in PM2.5 concentration. The decrease in concentration on the 30th was said to be due to a slight increase in southerly wind. Three vector arrows on the 30th look to point more vertically than their predecessors. Data for wind direction was missing for the 1st April however after this it can be seen that Easterly winds yet again increase the PM2.5 concentration before Westerly wind from the Atlantic Ocean disperse the pollution to acceptable levels from the 4th April onwards, as noted in Defra's annual report.

Lastly, in regards to investigating the source of the high PM episode, a Hysplit was performed to visualise the contributions of PM into London across Europe. Figure 8 was calculated from the 27th March – 4th April 2014 for PM2.5 arriving into London. High concentrations of PM2.5, the in order of ~80µg/m^3, are represented in red.

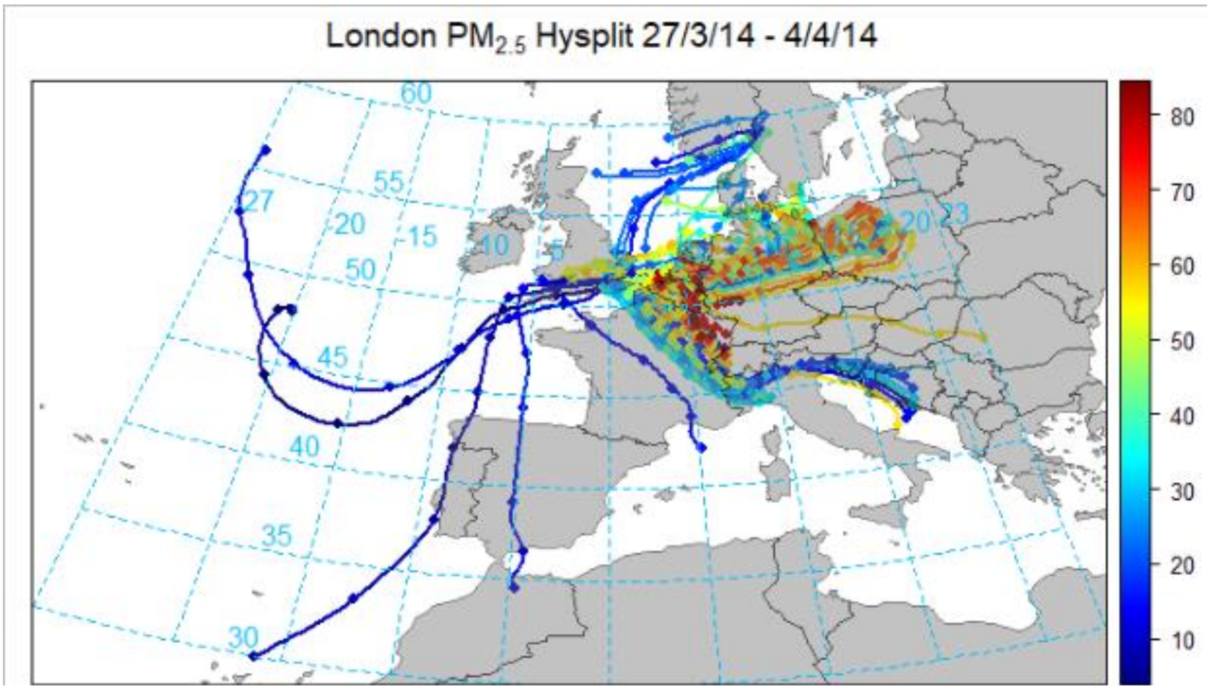

Figure 8: The Hysplit for PM2.5 arriving into London 27/3/14 - 4/4/14

High contributions are seen in Figure 8 from the North of France and Belgium as well as contributions of 60-70µg/m^3 from Germany and Poland. Very low contributions of ~10µg/m^3 can be seen from the Atlantic, Northern Italy, coastal countries about the Adriatic Sea, Norway, Spain, Portugal and Morocco. The Hysplit was much the same when observing PM10.

The high concentrations of PM2.5 from France, Belgium, Germany and Poland can be explain through these countries industrial factory locations.It was noted in the Defra annual report that a main contributor to this episode of high PM concentration in the UK was transported European vehicular emissions. However, there is no denying that coal powered power plant locations in Northern Europe hold a similar pattern to that of the PM2.5 contributions in Figure 8. Eight of the twelve largest single sources of carbon dioxide in Europe are found in Germany [14].

Figure 9: A map marked with the locations of Europe's coal power plants [15].

Another thing to note of the Hysplit in Figure 8 is the very low contribution of PM2.5 from the Sahara as Saharan dust. Remembering that this episode was heavily publicized for its involvement of Saharan dust, this may have overshadowed the real contributors of high PM2.5 concentration.

4.2 Perceived Risk

Public opinion or knowledge on an event is difficult to substantiate outside of national polls or questionnaires, none of which were available for this event. However, a useful resource in measuring public interest in a subject by time is Google Trends. Google Trends works by collecting data of Google internet searches (in this case in the UK) and producing a graph over time of the highs and lows of interest in that search. The highest peak would represent a time in which a phrase had its most searches or high interest across the timespan selected whereas a low point would represent a low number of searches or a disinterest in the phrase.

Figure 10 Shows two Google Trends graphs from 2006 – 2021 for the phrases ‘Air Pollution’ and ‘Air Pollution Effects on Health’.

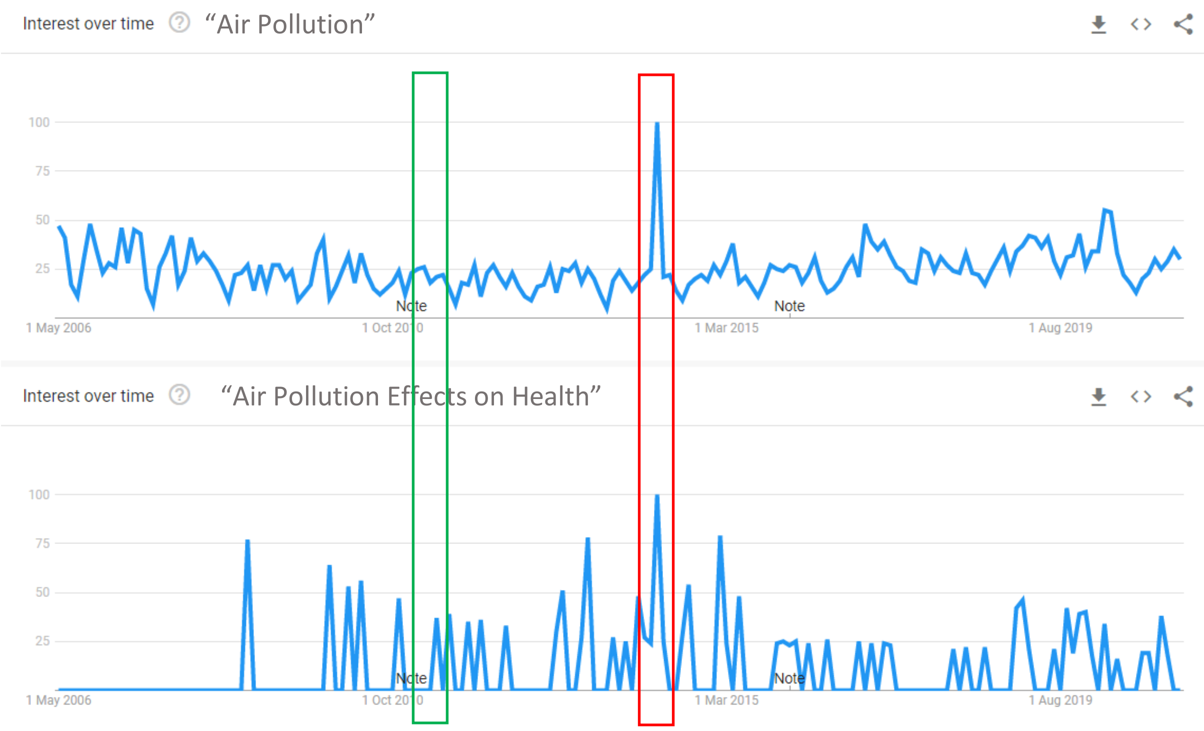

Figure 10: A Google Trends Graph displaying the volume of searches for “Air Pollution" and "Air Pollution Effects on Health" 2006-2021. March-April 2014 highlighted in red and April 2011 highlighted in green.

Highlighted in red on Figure 10 is the period of March-April 2014. Search volume on Google for the phrases “Air Pollution” and “Air Pollution Effects on Health” reached their peaks in April 2014, coinciding with the March-April Spring particulate episode involving Saharan dust. This event was greatly publicized in the media and news for its physical attribute of Saharan dust-fall. The phrase “Air Pollution” peaking in April 2014 as it did would indicate a greatly increased interest in the subject. More subtly, a peak in “Air Pollution Effects on Health” would indicate a public health concern with the event. It should be mentioned that on the 1st April 2014 Defra launched a new air pollution forecasting service which attracted some publicity however it is unlikely that this event would have caused such an increase in search traffic single-handedly, if at all.

4.3 2011 Episode

Highlighted in green on Figure 10 is the period of late-April 2011. The number of Google searches within the UK for ‘Air Pollution’ and ‘Air Pollution Effects on Health’ at this time were very small relative to the volume experienced in April 2014, indicating a comparatively great disinterest in the phrases. During this time however, the UK experienced a very similar Spring particulate episode to that of March – April 2014 only without the presence of Saharan dust.

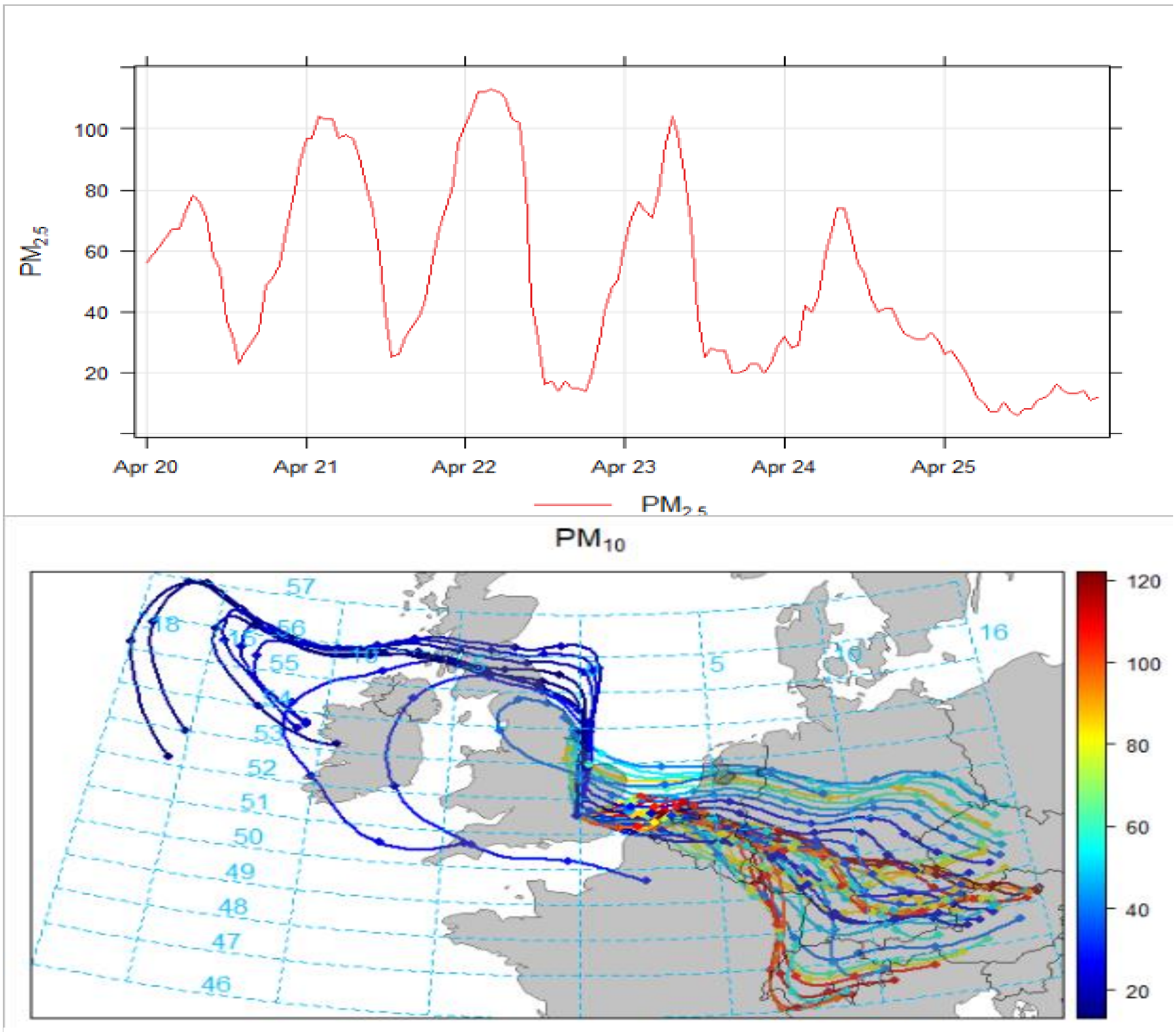

Figure 11: Top, a timePlot of the PM2.5 concentrations within Kensington, London 20/4/11 - 26/4/11. Bottom, a Hysplit for PM2.5 arriving into London for the same time period.

Figure 11 shows, firstly, that PM2.5 concentration in Kensington during the 2011 episode was similar to that of 2014 in that levels of concentration exceeded the EU threshold of 40µg/m^3 on several occasions over 6 days, reaches highs in excess of 110µg/m^3. The Hysplit indicates that, again, high concentrations of PM2.5 were received from the North-West of Europe. The most obvious difference in Figure 9's Hysplit to that of 2014's is the absence of any contribution from the Sahara.

Although there are many factors at play that could affect the public's perception, a case could be made that the lack of a physical attribute such of Saharan dust in 2011's episode meant there was a disinterest in the event compared to 2014 even though the human health risks were much the same. Media outlets such as televised news and newspapers would have had great effect on the public's perception of these events. It is evident that journalists brought attention to the Saharan dust-fall in 2014 through publications in the Daily Mail [16], Guardian [17] and BBC [18]. Not only were people interested in the event (spike in volume of 'Air Pollution' searches in the UK) but also concerned (spike in volume of 'Air Pollution Effects on health' searches).

Further evidence for the argument that the 2011 episode was greatly under publicized is the lack of data regarding hospital admissions or deaths associated with Spring particulate episode in 2011. An argument may be raised that the public took such great interest in the 2014 episode because of its high numbers of deaths and hospitalisations however the death rate would not have been known so shortly after the event.

It may be asked just how frequent periods of unacceptable PM concentrations occur. Spring particulate episodes occur 1 - 2 times a year most year but here we will briefly consider the rest of the year. Using Openair within R and the raw data from AURN, it was found that in Kensington, London between the years of 2010 and 2020 experienced 2,896 hours in which PM10 exceeded the EU hourly average limit of 50μg/m^3 and 10,011 hours in which PM2.5 exceeded its EU limit of 25μg/m^3. For the more harmful PM2.5, Kensington, London experienced unacceptable levels for 11.4% of the decade 2010-2020.

4.4 Deaths & Hospital Admissions

Further to the 600 deaths and 1,500 hospitalisations estimated by COMEAP, St Johns Ambulance and Asthma UK provide more evidence to a link between short-term PM exposure and negative health effects. Figure 12 displays the typical PM2.5 concentration for the UK in springtime alongside that of the two periods of high PM2.5 concentration experienced during the Spring particulate episodes in 2014 and their respective deaths brought forward thought to be caused by poor air quality [19].

	Mean daily $PM_{2.5}$ [μg m^{-3}]		Deaths brought forward: Number	Deaths brought forward: Percent of all-cause	Deaths brought forward: Increase in 2014 from typical levels
LN	Typical concentration[a]	18.0	26	1.85%	
	2014 (AURN)	49.1	69	5.00%	2.70 times
WM	Typical concentration[a]	19.3	29	1.99%	
	2014 (AURN)	41.9	60	4.23%	2.13 times
SC	Typical concentration[a]	10.9	16	1.13%	
	2014 (AURN)	21.4	31	2.21%	1.96 times
WA	Typical concentration[a]	15.1	14	1.56%	

Figure 12: Table of the typical PM2.5 concentration for the UK in springtime alongside that of the two periods of high PM2.5 concentration experienced during the Spring particulate episodes in 2014 and their respective deaths brought forward thought to be caused by poor air quality From [Mortality and emergency hospitalizations associated with atmospheric particulate matter episodes across the UK in spring 2014 - ScienceDirect] using data from the Office of National Statistics (ONS).

The data is split between 4 regions of the UK. LN being London, WM being the West Midlands, SC being Scotland and WA being Wales. The data shows the profound effect this period of heightened PM concentration had of the death toll in the UK.

On average, between the regions, deaths due to poor air quality would usually account for 1.9% of the total deaths. However, during the 2014 episodes, an increase in average PM2.5 concentration of 86% correlated to a 126% increase in deaths due to poor air quality. This was an average contribution to total deaths across the regions of 3.7%, over double the usual estimate.

	Mean daily $PM_{2.5}$ [$\mu g\ m^{-3}$]		Emergency *respiratory* hospitalisations			Emergency *cardiovascular* hospitalisations		
			Number of admissions	Percent of baseline	2014 increase above typical levels	Number of admissions	Percent of baseline	2014 increase above typical levels
LN	Typical concentrations[a]	18.0	43	1.71%		36	1.60%	
	2014 (AURN)	49.1	117	4.60%	2.69 times	97	4.27%	2.67 times
WM	Typical concentrations[a]	19.3	41	1.84%		34	1.72%	
	2014 (AURN)	41.9	88	3.91%	2.13 times	74	3.69%	2.14 times
SC	Typical concentrations[a]	10.9	21	1.04%		14	0.98%	
	2014 (AURN)	21.4	41	2.00%	1.92 times	27	1.86%	1.90 times
WA	Typical concentrations[a]	15.1	16	1.44%		12	1.35%	
	2014 (AURN)	34.5	36	3.25%	2.25 times	27	3.04%	2.25 times

Figure 10: Table of emergency hospital admissions for respiritory and cardiovascular problems compare with in and outside of the 2014 Spring particulate episode. Taken from [Mortality and emergency hospitalizations associated with atmospheric particulate matter episodes across the UK in spring 2014 - ScienceDirect]() *using data from the Office of National Statistics (ONS).*

A similar story is told through hospital admission data. Comparing the typical hospital admissions within these regions versus the admissions during the Spring particulate episode of 2014 sees an average increase of 125% and 126% for respiratory and cardiovascular admissions respectively. Again, this correlates with an 86% increase in PM2.5 concentration. How exactly PM2.5 exposure can damage human health was discussed earlier in this study. Knowing this, it is evident that this Spring particulate episode can be confidently said to have increase mortality and hospitalisations.

Furthermore, there is evidence to suggest that poor health occurred outside of these figures. An overnight poll of 532 asthmatics (of which there are 3.6 million in the UK) by Asthma UK on the 1st - 2nd April discovered that 30% had suffered an attack as a result of the poor air quality and 84% said that they had used their blue inhaler more frequently [20].

4.5 Emergency Calls

St Johns Ambulance hold data on 999 emergency calls made across the UK. Though more subtle, there was a correlation between the volume of 999 calls for an ambulance in London and the concentration of PM2.5 such that the number of emergency calls increased during the 2nd episode of the high PM concentrations suffered during Spring 2014 (31st March– 4th April). Figure 13 shows the volume of calls made per day divided by illness type. [21]

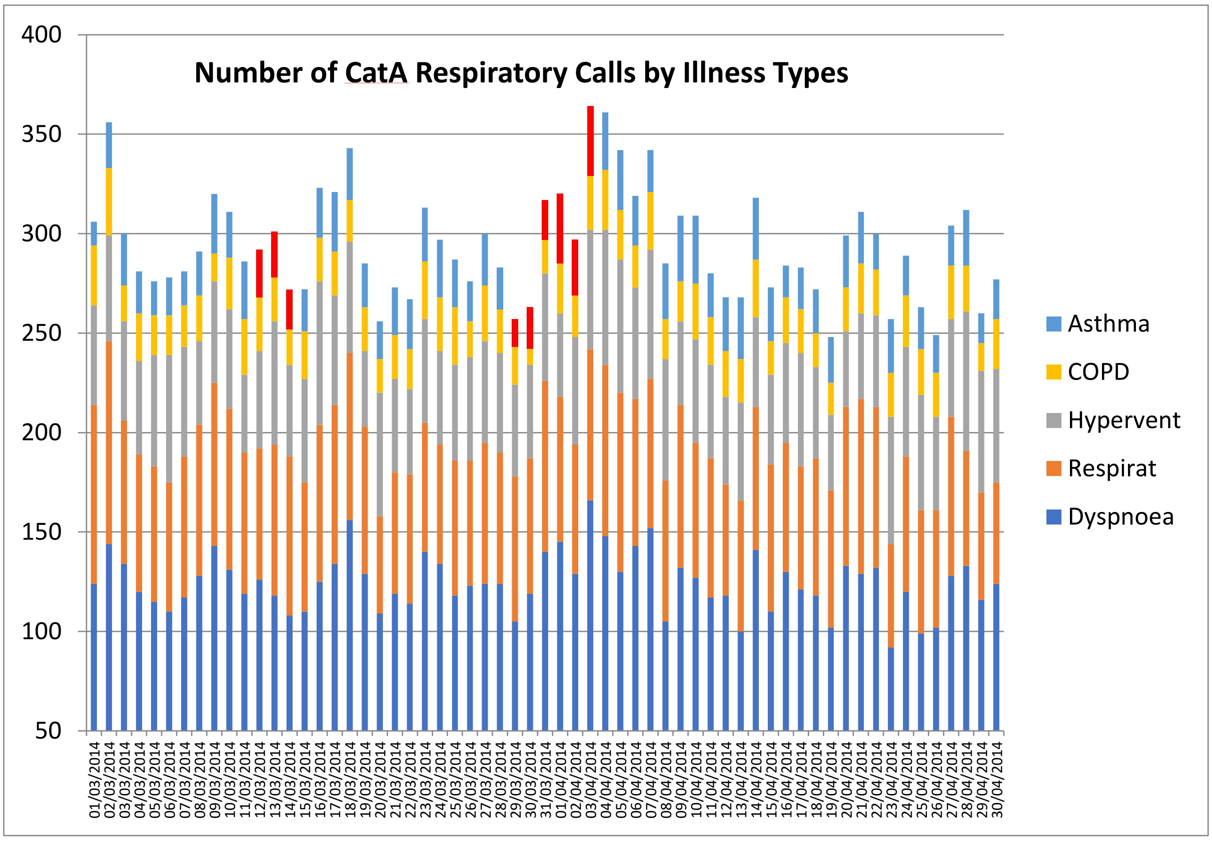

Figure 13: Bar chart displaying the number of 999 CatA calls recieved by St Johns Ambulance in London for the months of March and April 2014 John Thornes, Impact of the March/April 2014 Air Pollution Episodes' on Acute Morbidity Outcomes using London Ambulance Data, 2014.

A CatA incident is one that is considered life threatening by St Johns Ambulance. The illness types selected are all respiratory conditions. The bars with red caps indicate days of the Spring particulate episode.

The two peaks in the centre of Figure 13 that exceed 350 calls occur on the 3rd and 4th April 2014. Only two periods of time occured in which CatA respiratory calls exceed 300 calls per day for 3 consecutive days in the months of March and April 2014 and those are the 16th – 18th March and 3rd – 7th April. These periods succeed the periods of high PM2.5 concentration by several days, suggesting a lag in health effects from initial PM2.5 exposure. The increase in calls around these times regarding CatA respiratory issues serve as evidence of the negative health effects had by the short-term exposure to high PM2.5 concentrations. Further than negative effects on human health, the St Johns Ambulance data shows a negative effect on response times during these periods of heightened illness. Figure 14 shows the response times for St Johns Ambulance Services in London. A target of St Johns Ambulance is to arrive within 8 minutes of a CatA 999 call 75% of the time.

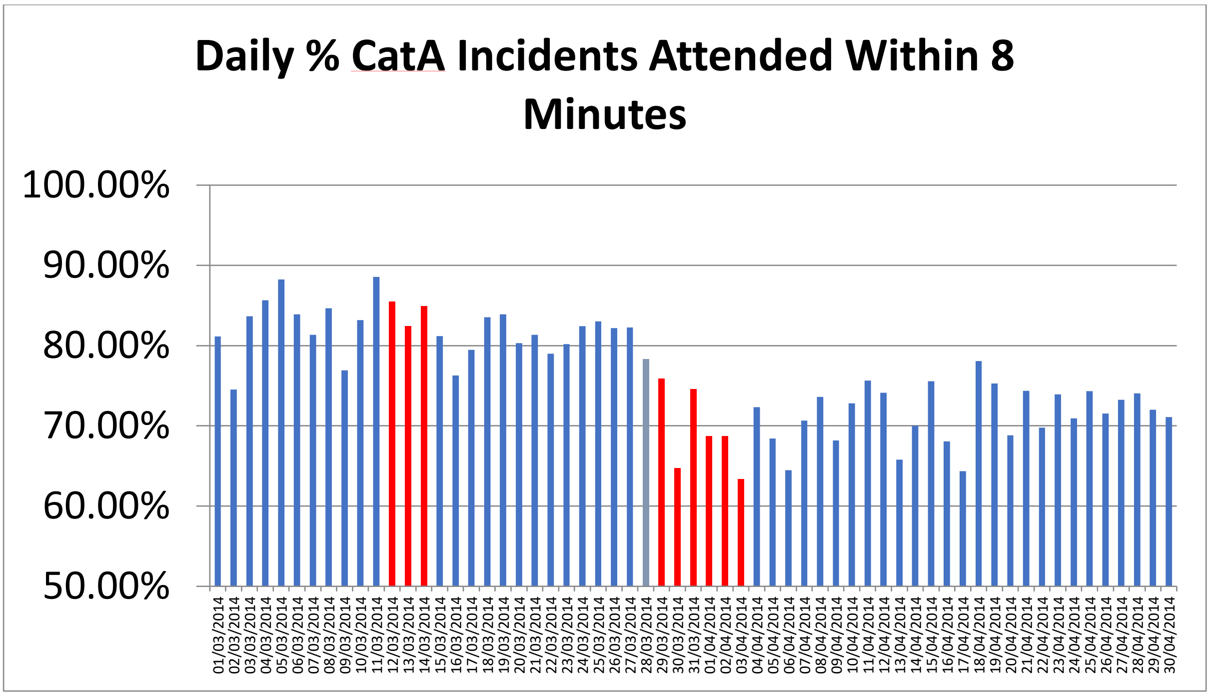

Figure 4: A bar graph representing the success in response time of St Johns Ambulances in London March - April 2014

Red bars indicate days during the Spring particulate episodes. Figure 12 demonstrates the effect that an increased demand in St Johns Ambulance services had on their response times. The 30th of March was the first day of the month in which St Johns Ambulance fell below their target of 75% of CatA cases responded to within 8 minutes. Taking the lag in health effect seen in Figure 13, this is likely due to the increase in PM2.5 concentration that started on the 28th March. Subsequently, the period of the Saharan dust episode saw a response time of 8 minutes for an average of 69% of CatA calls. For the rest of April 2014, St Johns Ambulance operated, on average, below their 75% target, though this cannot be entirely attributed to the rise in PM2.5 concentration, it could be possible that a lag in the onset of negative health effects caused by regional PM2.5 exposure put a strain on the St Johns Ambulance service even in the weeks following the event.

4.6 Mitigation Discussion

Although there are policies in place to reduce PM emission and poor air quality in the UK (as discussed earlier in the report), we know now that in the event of a Spring particulate episode polluted mass created in Europe can be transported regionally and can therefore not be stopped through policy within the UK. Instead, when these episodes occur the UK government and air quality organisations have to mitigate the effects to the public. The Daily Air Quality Index (DAQI) is a tool used to inform the public on forecasted air pollution and recommends actions to be taken in such scenarios. Numbered 1-10 and divided into 4 bands from low (1) to very high (10) it is similar to the pollen index [22]. Notifying the public of upcoming periods of poor air quality is vital in the mitigation of the short-term human health effects of PM2.5 and PM10 exposure. The DAQI is especially important to someone suffering from Asthma or chronic lung or heart disease.

Advice for different levels of pollution is given through the DAQI such as the avoidance of strenuous outdoor activity for the very young, elder or suffers of Asthma, lung or heart disease when the DAQI value is very high (10). Simple information such as this can save life and help the public prevented illness. The COVID-19 pandemic has seen the adoption of mask wearing in public places. Normalisation of mask wearing may encourage those most at risk of health effects due to heightened PM concentration to adopt this practice on days in which the DAQI values are high.

5. Conclusions

Through this study, it was found that the Spring particulate episode of 2014 had two distinct periods of high PM10 and PM2.5 concentration during April – March that exceeded the thresholds given by the EU of 50μg/m^3 and 25μg/m^3. The cause of these episode was known to be transportation of polluted air mass from Europe due to Easterly winds and was proven through the use of a windVector timePlot and a Hysplit. Evaluation of the public perception of this episode was achieved through the use of Google Trends. This suggested that the UK general public were very interested in / concerned about this period of poor air quality, most likely because of its appearance on main stream news channels, newspapers and blogs. Interest in similar episodes, such as that of 2011, was not identified even though this episode and others like it produced similar levels of PM10 and PM2.5 concentration and therefore carried the same health risks. The absence of the natural phenomena of Saharan dust-fall may had been to blame for the publics disinterest. However, statistics from the ONS suggest that this was a particularly bad episode that may have deserved its recognition, having 2.26 times the death toll of that of a time period outside of a Spring particulate episode. COMEAP estimated 600 deaths and 1,500 hospitalisations due to the episodes spanning April - March 2014. The ONS and St Johns Ambulance reported an increase in hospital admissions and CatA 999 calls due to cardiovascular and respiratory illness. St Johns Ambulance service reported poor service due to overwhelming 999 calls during this time.

Taking a step back, the UK is improving its air quality and has been able to hit EU and WHO targets set. However, any amount of PM exposure is harmful and all long periods of exposure, even low concentrations can cause chronic illness and shortened life expectancy. The public should be more aware of the risk to themselves and others through poor air quality, especially if they suffer from Asthma, chronic respiratory or cardiovascular illness. They should be aware of the DAQI and reference it should they be taking part in any strenuous outdoor activity. The UK has the geographic luck of being situated on the far west of Europe. Prevailing wind from the Atlantic sweep clean ocean air into our country and washes away many of the pollutants we produce, this is part of the reason western countries such as the UK, France, Spain and Portugal have, on average, better air quality than countries downwind such as Germany, Italy and Eastern Europe. Although Spring particulate episode have grave effects on human health, they only occur for 1-2 weeks of the year. Policy should still remain focused on the pollution the UK produce and how we can reduce it and improve air quality.

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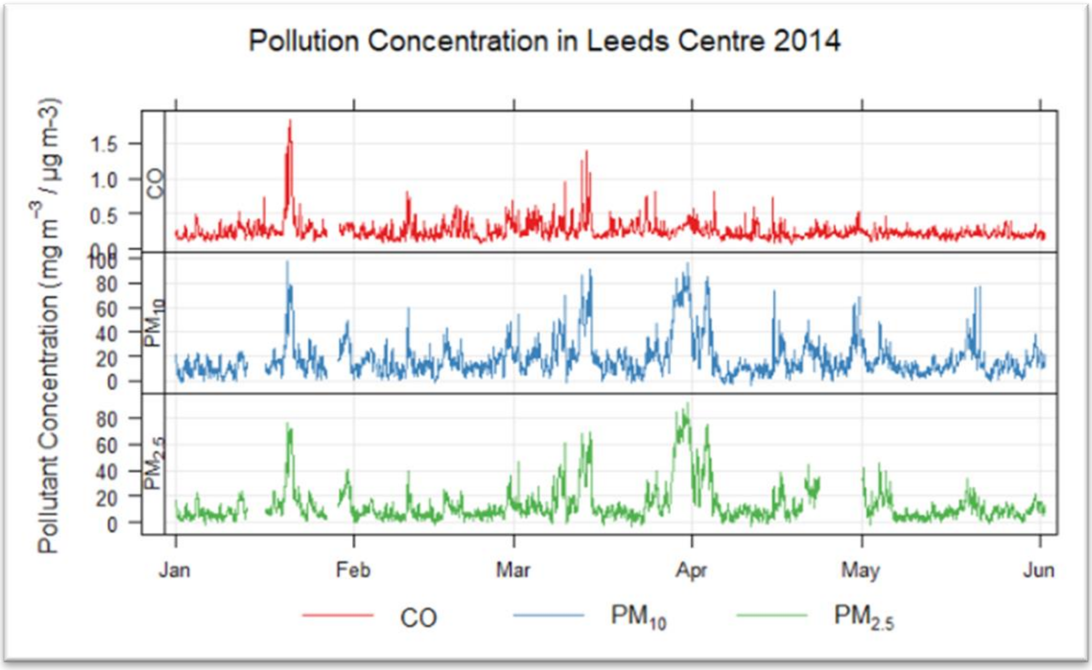
Appendix

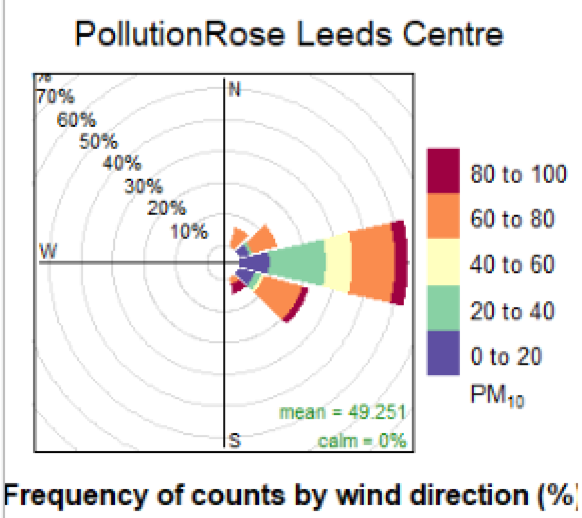
Additional Research Paper of interest:

M Vieno[1], M R Heal[2], M M Twigg[1], I A MacKenzie[3], C F Braban[1], J J N Lingard[4], S Ritchie[4], R C Beck[1], A Móring[1,3], R Ots[1,2], C F Di Marco[1], E Nemitz[1], M A Sutton[1] and S Reis[1,5] - The UK particulate matter air pollution episode of March–April 2014: more than Saharan dust

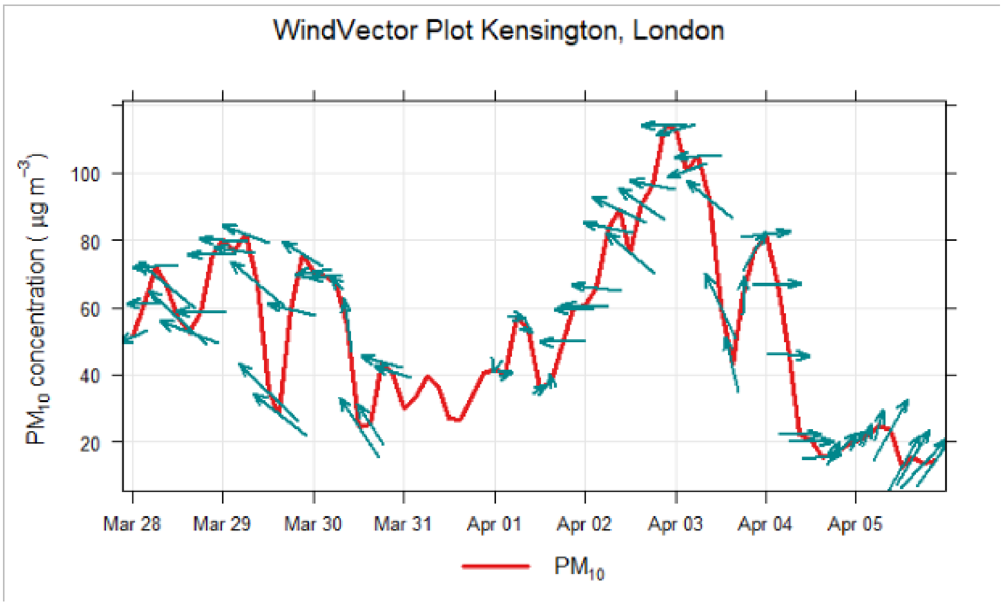
[The UK particulate matter air pollution episode of March–April 2014: more than Saharan dust - IOPscience]()



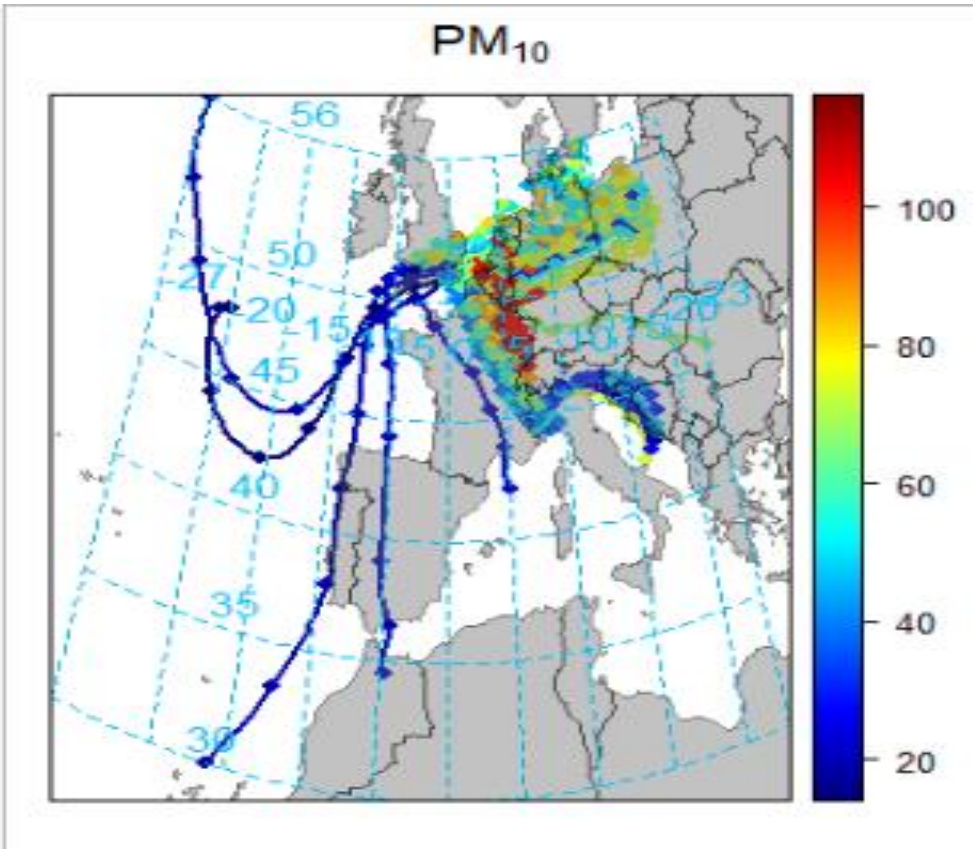

```
timePlot(leeds141, pollutant = c("co", "pm10", "pm2.5"), y.relation = "free", main = "Pollution Concentration in Leeds Centre 2014", ylab = "Pollutant Concentration (  mg m-3 / µg m-3)")
```




```
> pollutionRose(selectByDate(
+     leeds14,
+     start = "27/3/2014",
+     end = "31/3/2014"), pollutant = "pm10", main = "PollutionRose Leeds Centre")
```




```
> timePlot(kenselect, pollutant = "pm10",
+           windflow = list(scale = 0.1, lwd = 2, col = "turquoise4"),
+           lwd = 3, group = FALSE, avg.time = "3 hour",
+           ylab = "pm10 concentration (  ug/m3)", main = "WindVector Plot Ken
sington, London")
```




```
> trajPlot(selectByDate(traj, start = "27/3/2014", end = "4/4/
2014"),
+           pollutant = "pm2.5", col = "jet", lwd =2)
```